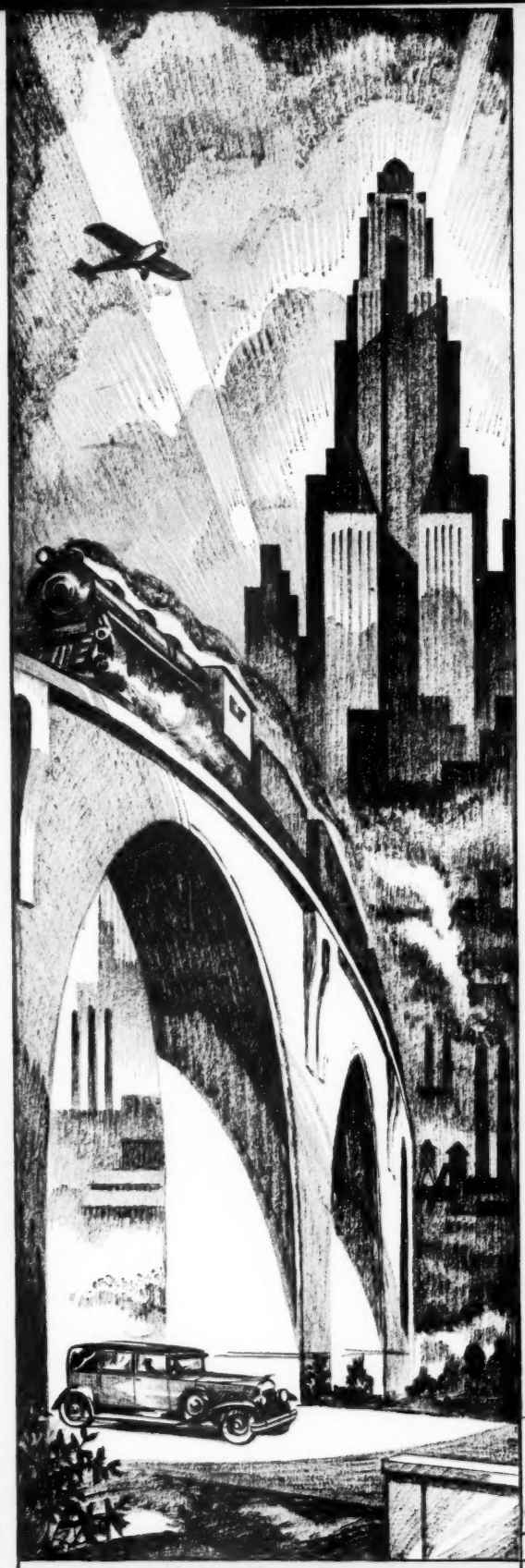
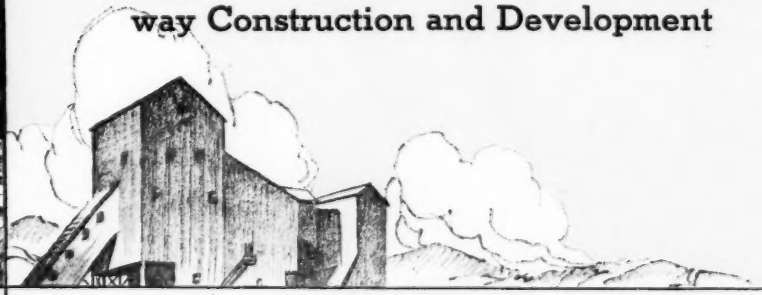


The CRUSHED STONE JOURNAL

In This Issue



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BULLETIN No. 1

The Bulking of Sand and Its Effect on Concrete

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Low Cost Improvement of Earth Roads with Crushed Stone

BULLETIN No. 3

The Water-Ratio Specification for Concrete and Its Limitations

BULLETIN No. 4

"Retreading" Our Highways

BULLETIN No. 5

Reprint of "Comparative Tests of Crushed Stone and Gravel Concrete in New Jersey" with Discussion

BULLETIN No. 6

The Bituminous Macadam Pavement

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Investigations in the Proportioning of Concrete for Highways

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The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

Contents

West Side Express Highway
in New York City

THE
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Past and Future Road Building[1]

By E. W. JAMES
Chief, Division of Highway Transport, Public Roads Administration—Federal Works Agency.

• With the pioneering work in highway construction largely completed, what of road building in the future? As Chief of the Division of Highway Transport of the Public Roads Administration, Mr. James is especially well qualified to discuss this subject, always of commanding interest to the crushed stone industry.

THE Silver Anniversary of the organization of the American Association of State Highway Officials is an opportune time to emphasize to the public the fact that the 25 years just ended has been a period of pioneering in highway construction. The National Government and the States have been pushing a far-flung system of improved highways into regions where no adequate roads existed to meet a demand for transportation facilities that was constantly increasing and had never yet been met. It was the greatest construction program in the world's highway history.

The American Association of State Highway Officials was organized in 1914, while the Post Road Law passed two years before was still running its administrative course. This Post Road Law was a kind of trial balloon to indicate what direction should be taken by cooperative road building in which the United States government might be interested. Operations under this law had already demonstrated that cooperation by the National Government should depend on contacts with the States, and on State funds rather than on counties or other local political units. It was made clear that the selection of roads for improvement should be somehow circumscribed if the results were to be cumulative and of increasing national benefit.

To accomplish this end, interested State officials and the Public Roads Administration studied the possibilities of direct State and Government cooperation, and the first Federal Aid Act of 1916 was the result.

At that time, eleven States had no adequate State highway departments, but this law and its amendments required their organization, and in time limited the selection of roads first to be improved to a system comprising not to exceed 7 per cent of the public road mileage of the country. The selected routes were to be coordinated and continuous at State lines, thus assuring the gradual completion of a national system of improved roads reaching into all parts of the country that had been settled during the period of pioneer development. This is our pioneer system of national roads. Today, it comprises 227,000 miles and is surfaced throughout almost its entire extent.

This system has been 20 years in building. It has many miles of road adequate to meet probable traffic demands for many years. But during these 20 years, the use of motor vehicles has increased enormously, and by a process of selection, directed by consideration of optimum service, a system of primary routes has been developed to accommodate the traveling public and the transportation of goods. Where we had 7½ million vehicles traveling ap-

[1] Radio broadcast during the Silver Anniversary, American Association of State Highway Officials, Washington, D. C., October 11, 1939. Photographs by courtesy Public Roads Administration.

proximately 34 billion vehicle-miles, we now have 30 million vehicles traveling approximately 260 billion vehicle-miles.

Consequently, there are many miles of improved road in the densely populated areas of the eastern States and of the north-central and Pacific Coast States which are no longer of sufficient capacity or of adequate design to meet the demands of current

UNIMPROVED ROAD NEAR BROOKINGS, SOUTH DAKOTA, ABOUT 1904.

traffic or to provide for the possibilities of the immediate future. These inadequacies of design will have to be corrected.

Many persons have the mistaken idea that these requirements mean the future building of a vast mileage of wide, boulevard-like roads all over the country.

As a matter of fact, in 12 representative States there are only 4,700 miles of rural road requiring more than two travel lanes to accommodate the present traffic. This is only about six-tenths of one per cent of the total road mileage. Already there are approximately 1,200 miles of such road. For the entire United States a system of about 30,000 miles of inter-regional road appears to meet every requirement that can be foreseen at the present time, and will comprise substantially all the highways which by location, convenience and economy in service represent the naturally selected routes for inter-regional or long distance travel. This system would represent less then one per cent of the total rural highway mileage of the country, and would serve probably 12.5 per cent of the total travel on rural highways. Of this rural system, about 7,700 miles would be designed for more than two lanes and in addition there would be approximately 2,500 miles of urban streets that would receive similar treatment.

This inter-regional system of highways is a conservative and reasonable undertaking, and based as it is on the first and only nationwide study of highway conditions might well constitute a major part of the national highway program during the next quarter century. But this undertaking would by no means constitute the whole program. Many miles of highway having a more local character have become outmoded, and reports from the States last year indicated that possibly as many as 40,000 or 50,000 miles of roads in our existing primary State highway systems are in urgent need of some degree of improvement—some relocation, a considerable amount of widening, and some outright rebuilding. In every State the highway officials are vigorously attacking the problem of providing these increasingly urgent highway betterments.

Attention should pointedly be called to the fact that no small part of the proposed betterments are not required by the merely physical demands of highway transport. A road surface 18 feet wide with two lanes for travel, each 9 feet wide, is of ample width for the passing of private cars only 5 feet 10 inches out-to-out of fenders, or even for the passage of trucks of 96-inch overall width, if we consider nothing but dimensions and widths. But this

MACADAM ROAD BUILDING IN VIRGINIA MOUNTAINS IN 1913.

condition may no longer be applied. We must consider something else than mere dimensions. The motor vehicle is operated by human beings and does not guide itself, and as speed increases, human control diminishes. The eye and the hand cannot hold the car to such a narrow track. The travel lanes must be somewhat wider to enable the driver properly to keep in line at present prevailing speeds, and

sight distances must be somewhat longer in order that he may maneuver safely when confronted with hazards. The curves must be easier and elevated on the outer side to enable him to travel around them without being forced out of the proper travel lane. Passing distances with clear visibility must be longer to enable vehicles to pass when necessary. All these details are incident to holding down the physical hazards of driving as speeds increase. The program of reconditioning and betterment does not indicate failure of highway engineers in the past to build well. They built to meet as nearly as possible the recognized conditions, which were, however, rapidly changing. Twenty-five years ago the immediate task was to provide facilities for an entirely new form of land transportation. There were no standards to guide the highway officials any more than there were standards to guide the manufacturers of the early motor vehicles who put dash boards and whip sockets in the earliest cars. The motor vehicle of today is the product of new knowledge and new requirements. So will be our new highways.

When the American Association of State Highway Officials was organized 25 years ago, there were only about 1,700,000 motor vehicles in the entire United States. Now at least five States have more automobiles and trucks within their borders than the whole country had in 1914. The rapid increase in the number of motor vehicles and the increased amount of driving done by cars year after year have compelled State highway departments to work on practically an emergency basis.

SECTION OF MACADAM PAVEMENT IN FAIRFAX COUNTY, VIRGINIA, PHOTOGRAPHED IN 1915.

Roads to meet the demands of the new and rapidly growing method of transportation were so desperately needed and the highways of practically the whole country were so deficient in both mileage and quality that there was little time to make exhaustive studies even of limited areas when the first Federal Aid Act was passed.

Correspondingly there was much less chance of serious error in selecting routes for improvement.

CONSTRUCTION OF 4-LANE CONCRETE ROAD ON LEE BOULEVARD, U. S. ROUTE 50, ARLINGTON COUNTY, VIRGINIA.

However, at that time, brief studies were made of the distribution of population, both urban and rural, and the quantities or values of agriculture produce, of mines and forests, and of manufacturers in each of the smallest political subdivision for which data were available. Routes were selected to connect the principal centers of population and to cross the areas of greatest production. Although this method of attacking a big problem was direct and highly simplified, the fact that probably less than one per cent of the routes were wrongly selected justifies its adequacy for that time. The fact that highway building in the United States has always been led by the demands of existing traffic also has guided selection and greatly assisted in avoiding serious error.

With respect to the type of road and the details of design, there was little to guide the roadbuilder in the premises. The new type of traffic with tractive effort developed at the rim of a wheel rather than under the hoof of a horse had produced an entirely new set of conditions.

Most of the principles now accepted as standard in road building have been worked out during the past 25 years. Now that highway officials in all States know how to construct roads for practically

any given condition, they remain confronted with even bigger problems of an economic nature. Engineering skill has run squarely into economic laws.

The big questions now are—How extensive a system of roads is required to serve the traffic needs of each State? Where shall the limited mileage be located? How can the roads be paid for? And, what type of roads should be used?

TRAFFIC ON THE MERRITT PARKWAY NEAR DARIEN, CONNECTICUT.

Planning surveys now being conducted in nearly every State in cooperation with the Public Roads Administration are giving the highway engineer new tools which will help him do a better job than has ever been done before. These new tools are simply facts as to how and where persons and goods move about on the public roads, and these facts can be so combined as to direct the financing and extension of the highway system.

It has been found that over 60 per cent of the vehicle-miles that American motorists roll up each year consists of a series of short movements averaging not more than 30 miles per trip, and the short trips are most characteristic of rurally owned cars.

This probably is hard to believe from the viewpoint of persons who drive bumper to bumper in and out of our large cities twice a day with thousands of other vehicles. BUT these facts are pretty well proved.

For instance, more than 82,000 motor vehicles daily cross the Hudson River in the New York Metropolitan area. Within 20 miles over 80 per cent of that traffic stops, and less than 4 per cent travels beyond the State lines of Pennsylvania, New York and New Jersey.

These conditions are indicative of two additional items in the probable highway program of the next quarter century. The first is the necessary betterments in and near large urban or metropolitan centers; the second is in the deep rural areas where the short range traffic predominates.

Near the great centers of population there will have to be many miles of modern, dual-line highways and streets similar to Chicago's Outer Drive or New York's West Side Improvement. These improvements are representative of a type of highway urgently needed in metropolitan and suburban areas and are quite different than the rural highways which also will be needed.

Metropolitan areas and their vicinities will be carefully studied, and depressed highways will be built. Undoubtedly, more beautiful designs utilizing broader rights of way on the surface will be sought. Whole lines of city blocks will be razed to provide rights of way for free-ways which will be landscaped, with no grade crossings and with attractive masonry structures. These will enhance the value of abutting property, not depress it as elevated structures would. The enhanced values will be partly recoverable to pay the costs of these expensive but imperatively needed improvements.

In the rural areas a system of large mileage constituting the farm-to-market or direct land-service roads will be improved. The type of this work will

GRADE SEPARATION IN NEWBURYPORT, MASSACHUSETTS.

be in strong contrast to that in and near metropolitan centers, but its design and adequacy for service will be equal, in that it will reflect as exactly as possible the demands of local traffic.

The Silver Anniversary meeting of the American Association of State Highway Officials marks the end of the pioneering era in road building and the beginning of the era in which engineering and eco-

nomic research will govern the kind and character of highways to a greater extent than ever before.

The question is constantly being asked—What are roads going to be like in another 25 years? And some persons have a rather fanciful mental picture. Actually, however, many miles of public roads in the United States will look about as they do today. The big changes will come in and near our cities. Indications are that about 10,000 miles of 4-lane divided highways will be needed in the next quarter of a century. These divided roads will be principally near cities where a great volume of traffic moves comparatively short distances and as part of a system of inter-regional highways.

These inter-regional highways will have rights of way wider than we have been accustomed to see, and the construction plans will include the complete development and beautification of the entire highway area. During the later years of the quarter century past considerable has been done in beautifying roadsides in many States. This work will be enlarged and extended. The highways are a part of the public property of the nation, and just as we take pride in our school houses and grounds, our court houses and in the thousands of municipal and State buildings and grounds that are scattered throughout our land, so will the public take a greater pride in seeing those areas which constitute the public land holdings devoted to highways put into presentable and attractive, even into a beautiful, condition. More of our general public will find satisfaction in this than in the care and attention devoted to the maintenance of scattered public holdings, however desirable and necessary these may be. Wherever these inter-regional roads penetrate in the next quarter century the countryside will present a more attractive appearance and the roads and their structures will be an ornament fitting appropriately into the beauty of the surrounding landscape and enhancing it.

During the quarter century there will be a heavy program of railroad and highway grade crossing elimination and our main highways will be characterized by more structures and fewer interruptions to traffic. The building of a system of secondary roads for a definite local service will provide space to take care of the rural short haul travel.

The entire plan will be predicated on studies of the needs of each community and the whole underlying thought of the highway program for the next 25 years will be to build only just what is needed, just where it is needed, just when it is needed.

Crushed Stone Industry Well Represented at National Safety Congress

DURING the 28th National Safety Congress held at Atlantic City the week of October 16, the Cement and Quarry Section met on Tuesday and Wednesday with attendance at each session substantially in excess of 50. This represented a decided improvement in attendance over recent years, showing renewed interest in the important activities of the Section which should be gratifying to its officers. At the luncheon held at the Ambassador Hotel on Wednesday, Otho M. Graves, President of The General Crushed Stone Company, and Past President of the National Crushed Stone Association, acted as Toastmaster. The selection of Mr. Graves for this important post not only reflects credit upon, but was also a courteous recognition of the industry in which he has participated so actively for many years.

Representation from the quarrying industry showed a big improvement over recent years and included the following:

Wm. H. Baker, J. E. Baker Co., York, Pa.

J. R. Boyd,, Administrative Director, National Crushed Stone Assn., Washington, D. C.

F. J. Buffington, New York Trap Rock Corp., New York City

Otho M. Graves, President, The General Crushed Stone Co., Easton, Pa.

M. P. Greer, Marquette Cement Mfg. Co., Cape Girardeau, Mo.

T. W. Jones, New Haven Trap Rock Co., New Haven, Conn.

Stirling Tompkins, President, New York Trap Rock Corp., New York City.

A. L. Worthen, Vice President and General Manager, New Haven Trap Rock Co., New Haven, Conn.

H. F. Yotter, Insurance Supervisor, The General Crushed Stone Co., Easton, Pa.

The following officers were elected for the ensuing year:

GENERAL CHAIRMAN—P. N. Bushnell, Missouri Portland Cement Co., St. Louis, Mo.

VICE-CHAIRMAN—R. W. Dittmar, Universal Atlas Cement Co., Hudson, N. Y.

SECRETARY—A. J. R. Curtis, Portland Cement Assn., Chicago, Ill.

NEWS LETTER EDITOR—Jack Dempster, Canada Cement Co., Ltd., Montreal, P. Q., Canada.

Research Needed on Accelerated Weathering Tests

By A. T. GOLDBECK

Engineering Director, National Crushed Stone Association, Washington, D. C.

• **The durability of concrete exposed to the weather continues to be a fascinating subject for study. Investigations are needed to develop definite methods for determining those qualities of materials which influence durability under different conditions of exposure.**

FOR MANY years accelerated weathering tests on aggregates or on concrete have been made with the idea of determining if these materials would be likely to produce durable structures. Accelerated tests have taken the form, either of a laboratory freezing and thawing test or of a "soundness" test made with alternate cycles consisting of immersion in either a sodium sulfate or a magnesium sulfate solution, followed by a period of drying. There is a growing feeling among those who have given thought to the matter that, although accelerated weathering or soundness tests as practiced in the past frequently have given valuable indications, still, they are not as reliable or as indicative as they should be. Perhaps one of the reasons for the lack of correlation which has been noted between laboratory tests and service behavior is that many different conditions contribute to lack of durability in service which cannot be simulated by a single laboratory soundness test, performed in accordance with some standarized method which has been designed to imitate only one of the destructive forces of nature.

Structures are subjected to different weathering conditions depending upon their design, their geographical location, their contact with water, their exposure to freezing and thawing, and to changes in temperature and no doubt to other destructive influences. In view of these facts no single accelerated laboratory soundness test is likely to be universally applicable for judging the resistant value of aggregates or of concrete.

It seems to be appropriate that a serious attempt be made to devise more suitable and more comprehensive soundness tests for concrete and for aggregates than now exist. To approach this attempt with understanding it is well to give thought to the various physical and chemical phenomena which might act to bring about unsoundness or lack of durability in a structure when it is exposed to the weather. This, of course, is a task for a number of individuals pooling their specialized knowledge, rather than for any single individual. However, the following discussion may serve to initiate a line of thought for others to criticize, augment and finally perfect. Accordingly, an attempt, however crude and incomplete, will be made to discuss briefly some of the matters which should be considered in connection with the development of soundness tests for aggregates, or soundness tests for concrete.

Concrete Exposed to the Weather

Since our problem is to discover how to predetermine the durability of concrete and also how to test aggregates for exposed concrete, perhaps we had best start by asking ourselves, what are the factors which can produce internal forces so great that destruction of the concrete can result? Offhand, the following list of influences suggests itself:

1. Changes in temperature and moisture.
2. Freezing and thawing.
3. Chemical changes.
4. Mechanical effect of salt crystallization within the concrete.

Along with the above influences there must also be considered certain inherent characteristics of the aggregate or of the cement, or of the concrete itself which undoubtedly must influence the weathering resistance of concrete. These are:

a. Density of concrete
b. Absorption of aggregate or concrete
c. Resistance of aggregate to freezing and thawing
d. Cement factor
e. Cement characteristics
f. Coefficient of expansion of the aggregate
g. Water-cement ratio
h. Smoothness of the aggregate's surface
i. Characteristics of the surface roughness—For illustration, whether the roughness is abrupt and precipitous, or undulating.

j. Shrinkage characteristics of the mortar or concrete.

Then, too, of foremost importance, comes the kind of exposure to which the concrete is subjected. This might involve:

1. Continuous contact with water.
2. Intermittent wetting and drying.
3. Exposure to moisture on one side and to atmospheric temperature changes on the other.
4. Exposure to large temperature range or to rapid temperature changes.
5. Unusual drying conditions.

The above lists are not complete, but they suggest at least some of the considerations which deserve study in their relation to unsoundness of concrete. They also suggest that a soundness test which merely is aimed at determining the behavior of the aggregate under the repeated internal expanding effect of salt crystallization, or of ice formation, may not be sufficient to fully determine the suitability of aggregate for making sound concrete. Further, they suggest that a test applicable to one kind of weather exposure may have no significance as applied to another kind.

Let us give some thought to the items above mentioned to determine what bearing they may have on the durability of concrete. Perhaps in this way we shall be led to conclusions regarding the kind or kinds of test to be included in a fundamental research on investigations of soundness.

Concrete Exposed to the Weather

1. *Changes in Temperature and Moisture.* We, of course, are all familiar with the fact that most exposed concrete structures are subjected to temperature changes daily and also seasonally. The seasonal changes are generally of a greater range than the daily changes. They are slowly occurring in contrast with the daily changes, which at times are not only abrupt, but also are of wide range. These abrupt changes, because of the slow rate of heat transfer through the concrete, may result in a wide difference in temperature between the surface and the interior of the concrete in a structure. Wide differences in temperature can cause high stresses which may be sufficiently great in tension to crack the concrete at the surface and thus produce incipient disintegration. Tests made in the National Crushed Stone Association laboratory have shown that a range of temperature from 70 to 135° F., repeated abruptly sixty times will cause serious cracking of the surfaces of 6-inch square concrete beams, and undoubtedly this same phenomenon occurs in greater or lesser degree in many structures.

In Fig. 1 are shown typical curves indicating the growth in length of concretes due to sudden changes in temperature from 70 to 135°F., the concrete remaining continuously wet. A great deal of tensile stress, enough to produce cracking, is clearly evidenced by the photograph in Fig. 2, showing the appearance of one of the specimens after 60 cycles of the 70 to 135°F., temperature range produced within the specimens by plunging them from one water bath into another.

One cannot discuss temperature change without considering the coefficient of expansion of aggregates. When it is realized that the solid volume of the combined aggregates may be as much as three-

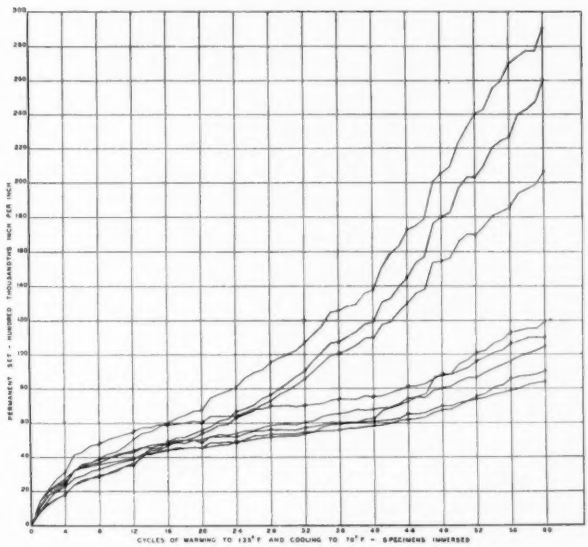

FIGURE 1.

CURVES SHOWING GROWTH IN LENGTH OF CONCRETE SPECIMENS CONTAINING DIFFERENT COARSE AGGREGATES, SPECIMENS SUBJECTED TO RAPID CHANGES IN TEMPERATURE FROM 70 to 135°F.

fourths of the volume of the concrete, and that the solid volume of the coarse aggregate may be one-half the volume of the concrete, the very great importance of the expansion and contraction of the coarse aggregate can well be imagined.

The higher the coefficient of expansion of the aggregate, the greater must be the difference in ex-

pansion or contraction between the surface and the interior of a concrete member which is exposed to external temperature changes and hence the greater must be the surface stress produced. Consequently, the value for coefficient of expansion of the aggregate surely enters into the problem of deciding on suitable durability tests for a given exposure condition. As above stated, these expanding and contracting effects may produce high tensile stress in the surface of the concrete, enough to produce serious cracking.

FIGURE 2.

SURFACE CRACKING OF CONCRETE DUE TO 60 CYCLES OF RAPID TEMPERATURE CHANGE FROM 70 TO 135° F.

There is another possible temperature effect. If the aggregate has a coefficient of expansion different from that of the mortar, there must be relative movement, or a tendency for relative movement within the mass of concrete during times of temperature change. This relative movement may be augmented by the fact that the mortar expands when it gets wet and shrinks when it dries out. So that with changing conditions of moisture and changing temperature conditions, we theoretically have a mass of material, the component parts of which are tending toward relative motion with respect to one another. Obviously, internal stress must be set up when these motions meet with resistance. The stresses may be high tension in the mortar or shearing stresses, or bond stresses may be produced between the coarse aggregate and the mortar. It is quite conceivable that these stresses may attain sufficient magnitude to cause numerous tension cracks in the mortar, or if the aggregate is smooth enough it is possible that bond failure will result. There is quite a difference in bond resistance between the mortar and the course aggregate, depending upon the roughness of the aggregate. This is particularly so when the mortar has been allowed to shrink by drying out, a condition which it frequently has in service. This phenomenon will be discussed a little later.

2. *Freezing and Thawing.* There seems to be little doubt that most evidences of lack of durability of concrete occur in structures exposed to freezing conditions. If these structures could be kept continuously dry, there would be no effect from freezing and thawing except that which might occur as the result of stresses produced by temperature change. Ice occupies a volume roughly ten per cent greater than that of the water from which it was formed and, consequently, if the pores of a concrete structure were completely filled with water this expansion alone would account for the disintegration which sometimes occurs in concrete; but disintegration does not always occur in concrete structures exposed to water action.

It would seem reasonable to believe that the denser the concrete, that is, the lower the percentage of voids, the more durable will that concrete be upon exposure to freezing conditions and, in general, that supposition is borne out by experience. Only a small amount of the mixing water used in a concrete mixture is necessary for the hydration of the cement and the excess water, if it remains in the concrete, creates porosity to a greater or lesser extent, depending upon the final amount of excess water in the mixture. This excess water is needed to produce the necessary degree of workability required for placing the concrete. Therefore a certain amount of pore space seems to be unavoidable. Excess water, however, is the most important factor in making for lack of durability under freezing conditions. It would be desirable if this excess water could be extracted before the concrete had hardened, thus making it possible to draw the solid particles of aggregate and cement closer together

to the end that porosity would be greatly decreased. A high amount of water has still another effect, namely, a weakening of the concrete mass due to dilution of the cement paste, and, furthermore, this excess water is apt to migrate to the surface which is exposed to the weather. There are other conditions which make for lack of density and therefore lack of durability of the concrete, but these cannot all be discussed at present.

As above stated, if the voids or pores in concrete were completely filled with water during times of freezing, the result would be extremely disastrous and as this disintegration does not always occur, it is probably the case that the internal voids in the concrete are not completely filled with water and this fact has an important bearing on the method to be pursued in treatment of the specimens prior to making the freezing tests. Consideration should be given to:

1. Whether to insure the complete filling of the voids with water, or
2. Whether they should be partially filled and, if so, to what extent?

No doubt the nature of the water exposure to which the structure will be subjected should be taken into consideration in connection with the laboratory test method to be pursued. The indications are that there may have to be more than one test method, depending upon the exposure.

Some structures may be subjected to room temperatures on one side and to atmospheric temperatures and water conditions on the other side. Some structures may be in contact with water continuously below the ground line in such a manner that water may rise by capillarity through the concrete to that portion which is exposed to freezing conditions. Should this be taken into account in connection with the accelerated freezing test? It is possible that ice lenses might form by this continuous feeding of capillary water to certain portion of the concrete subjected to freezing action.

Ice is a solid and its coefficient of linear expansion is approximately 0.000028. Apparently, then, after the ice has formed in the concrete, it will continue to contract as the temperature falls and thus, even though the ice completely filled the internal voids in the concrete mass at the instant it was formed, it would tend to contract away from the sides of the internal voids as the temperature falls because this value for the coefficient of expansion or contraction of ice is roughly four times that of concrete. Theoretically, a partial vacuum is thereby created in the pores under falling temperature. If, through the effect of capillary moisture, there is a tendency for these voids to become filled with water which is later frozen, then as swelling of the ice takes place as the temperature rises, this extra ice might exert tremendous expanding effect and cause a lot of damage. Should not freezing tests be investigated which involve specimens subjected to freezing on one side and to water at laboratory temperatures on the other side?

The above discussion may be summed up by saying that evidently the conditions of water exposure and degree of saturation of the concrete seem to be of highest importance and need a thorough investigation.

3. *Chemical Changes, Including Solution or Change in Composition of Concrete with Resulting Volume Change.* It is not the function of this paper to discuss all of the various causes of the disintegration of concrete, but chemical changes in aggregates do bring about unsoundness and they should not be overlooked in making a predetermination of the soundness of aggregates. Perhaps one of the most striking examples of a chemical change in aggregates occurs in blast furnace slag at times when, for some reason, there has been incomplete combination of the limestone or dolomite with the siliceous portion of the ore. The result is the formation of quicklime which may slake in the concrete several months after it has been placed. This is a type of aggregate unsoundness which does considerable harm to the concrete, but which is not detected readily with the ordinary soundness tests. A special test is needed to determine the soundness of materials of this nature.

Certain chemical inclusions in aggregates, such for illustration as sulphide of iron in the form of marcasite, have been mentioned as potential sources of unsoundness because of subsequent volume change which can take place if these chemical constituents combine with others in the concrete with the resulting formation of compounds having very high volume in comparison with that of the original constituents. What are the conditions under which such materials are harmful? Would they be harmful if the concrete were dense and relatively non-absorbent or only if the concrete is weak and porous and subject to infiltration of water? If mar-

casite is a possible source of unsoundness, then it would seem that we need a test other than our present accelerated soundness tests to determine the extent of its harmfulness. Furthermore, we need careful investigational work involving concretes of different strengths and densities subjected to different exposure conditions involving complete immersion, alternate wetting and drying and storage in air. No doubt there are other chemical effects which should be similarly investigated and which will occur to those who have encountered them. The above are merely suggestions.

4. *Mechanical Effect of Salt Crystallization within the Concrete.* All of the constituents in concrete are not insoluble when exposed to water. For illustration, the calcium hydrate given off by the cement in the presence of water gradually goes into solution and upon contact with the air it is changed to calcium carbonate or perhaps to calcium sulfate. It is not impossible that soluble salts in the earth may be carried by capillary action and be deposited in the pores of the concrete. Crystals of these salts may exert expanding action. This possibility has been suggested and probably warrants further investigation. What are the conditions under which this action can take place and how serious is it, if indeed it has any significance whatever? The destructive effect of salts used for ice removal are now well established and well known. Their effect may be both chemical and physical. They probably hasten the removal of the calcium hydrate from the concrete and also they probably produce more cycles of freezing and thawing during the winter season because of a lowering of the freezing or thawing temperature.

Characteristics of Concrete and Aggregates

It needs no investigational work to substantiate the statement that the characteristics of the concrete, particularly with regard to its strength and density play a major part in the degree to which disintegration may take place under freezing and thawing conditions. It has been observed by a number of investigators that a coarse aggregate which is not of the soundest character may still give perfectly satisfactory results in a dense, strong concrete, but may be a contributing cause to the failure of weak, porous concrete. What is the relationship between the unsoundness of aggregate and the unsoundness of concrete, depending upon the characteristics of the concrete and the exposure conditions? An economic question is here involved for there are a number of sections of the country where entirely sound aggregate does not exist.

The nature of the failure of coarse aggregate in a soundness test requires study. Two aggregates may have the same percentage of loss, yet one may not cause disintegration of the concrete, the other serious disintegration. Certain shales and certain cherts are typical examples of the above two kinds of aggregates.

There are a number of factors needing study in the general investigation of concrete durability. A study of cement, not only of chemical composition, but also of fineness is a study in itself. The older cements had a higher percentage of coarser particles as contrasted with the present day cements, most of the particles of which pass through a No. 200 sieve. Studies are needed to determine the possible changes in gradation of the fine aggregate which may be needed because of the extreme fineness of the present day cement. Formerly, the coarse portions of the old cement extended up to the No. 50 sieve and sometimes coarser. Possibly we need more fine material in our sands to supply the lack of coarse particles in our present day cements.

The question of expansion of the aggregates has already been touched upon. There is a wide range in thermal expansion of aggregates and a brief table of coefficients of expansion (Table No. 1) is included herewith taken from the bulletin entitled, "Thermal Expansion of Typical American Rocks" by John H. Griffith, Bulletin 128, Iowa Engineering Experiment Station, Ames, Ia. Prof. Griffith's bul-

TABLE I

AVERAGE COEFFICIENTS OF LINEAR THERMAL EXPANSION OF ROCKS FROM VARIOUS SOURCES (Range from 32°F. to 212°F.)

Coefficients of thermal expansion (multiply numerals by 10-7)

Chert	Quartzite	Granite	Limestone	Sandstone	Slate	Marble	Basalt	Porphyry	Authority
65	59	44	44	54	45	45	27	30	Griffith (author)
		40	45	55	58	45			Merriman [3]
		46		53		65			Hodgman [4]
		36	28	52	52	38			U. S. Arsenal [5]
		45	36			55			Marks [6]
		48		95		57			Merrill [7]

[3] Merriman, Mansfield, ed. "American Civil Engineers' Pocket Book." 1st ed. John Wiley & Sons, Inc., New York, 1911.
[4] Hodgman, C. D., ed. "Handbook of Chemistry and Physics." 19th ed., p. 1159. Chemical Rubber Pub. Co., Cleveland, Ohio, 1934.
[5] Withey, M.O., and James Aston. "Johnson's Materials of Construction." 7th ed., p. 614. John Wiley and Sons, New York, 1930.
[6] Marks, Lionel S., ed. "Mechanical Engineers' Handbook." 3rd ed., p. 305. McGraw-Hill Book Co., Inc., New York, 1930.
[7] Merrill, G. P. "Stones for Building and Decoration." 3rd ed. John Wiley and Sons, Inc., New York, 1910.

letin gives a much more extended table showing the thermal coefficient of expansion of rocks from different sections of the United States. It is interesting to note, however, that some rocks have more than twice the coffiecient of expansion of others; thus a chert has an extremely high coefficient of expansion and some of the limestones and trap rocks have low coefficients. These figures have significance in connection with the development of internal stress due to temperature changes and they undoubtedly have influence on the extent to which cracks take place in concrete and possibly also point to temperature coefficient as a factor to be reckoned with in connection with concrete disintegration. It would seem then that in investigating the coarse aggregate for its effect on the durability of concrete, the temperature coefficient should not be neglected.

Smoothness of Aggregate Surface

The smoothness of the surface of aggregates probably influences the bond with the mortar. It may readily be shown by calculation that a surface composed of square pyramids whose slant height is equal to the diameter of the base has an exposed area equal to twice that of a flat surface of similar dimensions. If the coarse aggregate has a different coefficient of expansion than that of the mortar or if for any reason it expands at a different rate than that of the mortar there is at least a tendency for bond stress to develop and it seems logical to suppose that the effect of bond stress will be decreased as the area in bond is increased. The roughness characteristics of a rough surface also play an important part in the bond resistance. For illustration, an undulating surface is not as effective as a surface having precipitous faces. A very striking illustration of the effect of roughness of surface is shown in Table II:

TABLE II
BOND TESTS TO DETERMINE ADHESION BETWEEN MORTAR AND AGGREGATE

Surface Condition of Aggregate	Series I	Series II	Series III
		(lb. per sq. in.)	
Porous, rough face	350	260	235
Rough	240	275	230
Concoidal fracture, smooth	285	170	45
Smooth	120	45	—
Very smooth	195	40	25
Fairly rough	250	185	160
Rough	215	300	245

Series I Cured 28 days in water.
Series II Cured 28 days in water, then 28 days in air.
Series III Cured 28 days in water, then 25 alternations of drying and wetting.
Average 28-day strength of the 1:2 mortar used in above tests was 445 lb.

The above test results were obtained by embedding in cement briquettes pieces of aggregate shaped to a square cross-section one inch on a side with the natural face of the aggregate placed at the minimum cross-section of the briquette. The remaining portion of the briquette was filled with mortar. It is interesting to note that although all the briquettes when kept immersed in water had fairly high bond strength, there was a wide difference in bond strength in those briquettes which were allowed to dry out or which were alternately subjected to wetness and dryness, thereby creating shrinkage and expansion of the mortar. Those aggregates with a rough surface retained their bond whereas those with a smooth surface either lost their bond completely or the bond was greatly reduced. Perhaps this is a factor which needs further investigation in its relationship to the question of durability of concrete.

Shrinkage Characteristics of the Mortar or Concrete

Some cements shrink more than others and so also do some mortars depending in part upon a number of factors all of which cannot be discussed, but they involve the fineness of the aggregate and of the cement; also the water content. High shrinkage means high relative movement and therefore high stresses within the concrete. Surely these are important matters in connection with the durability of concrete.

Exposure Conditions

Considering durability tests, the kind of exposure to which the concrete will be subjected needs be taken into account. If the concrete is subjected continuously to water exposure without freezing action, then it would seem that the aggregates should be investigated or at least considered as to their characteristics for this type of exposure. In general, most aggregates from an engineering standpoint are little affected by water exposure; certainly no more so than the mortar which binds them together.

The question of intermittent wetting and drying of concrete needs consideration because of the possible production of swelling and shrinkage of the mortar with their attendant production of stresses within the concrete including both tensile and bond stress. So far as the aggregate is concerned, here bond strength may become important.

When concrete is exposed to moisture on one side and atmospheric temperature on the other, water

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Industrial Price Policies in This Emergency[1]

By HAROLD G. MOULTON
President, The Brookings Institution.

• Recognized as one of the most noted economists of the day, Dr. Moulton in this significant and penetrating analysis of the industrial price situation and its relation to industrial recovery, discusses a problem of vital concern. As a guide to industrial policy, the importance of his observations cannot be over-emphasized and a careful reading of Dr. Moulton's address is earnestly recommended.

AS EVERYONE knows, the outbreak of war in Europe resulted in an immediate and striking advance in commodity prices in the United States. In the first two weeks of September the wholesale price index of all commodities rose some 6 per cent and many raw material prices advanced as much as 25 per cent. The question of the hour became—Are we entering upon a new era of inflation comparable to that of the World War period? The advance ended in mid-September, and the last four weeks have shown a slight recession. Hence the present moment of suspense is a highly propitious one in which to discuss industrial price policies in this emergency. If we are to analyze the problem adequately, it is essential that we place the American financial situation in a world setting.

Financial trends throughout the world in recent years have been highly disquieting. The disorganization of the international exchanges and the breakdown of monetary and financial systems during the great depression were not followed by a period of financial reconstruction and normal business expansion. Instead of a restoration of international economic equilibrium, we have witnesed a continuance of foreign exchange controls and a further great shift of liquid financial resources to the United States. In lieu of a well-balanced *world recovery* from a *world depression*, we have had widely varying degrees of business activity in different countries, reflecting in the main the intensity of the stimulus applied in the form of government expenditures for relief purposes or for military objectives. In place of a progressive reduction in public indebtedness and a lightening load of taxation, government debt has nearly everywhere been increasing at a rate comparable to that of war-time. At the end of six years which should have been years of sound recovery and expansion, it cannot be said that world financial stability had been achieved, or even approached.

In the light of this background, it is hardly too much to say that the coming of a new war in Europe raises economic and financial problems of wholly unprecedented importance for the entire world. The imposition of new war costs upon already overburdened financial systems imperils economic and financial reconstruction everywhere—in the United States and other neutral nations as well as in the countries which are at war.

This statement is made in full consciousness of the fact that at the moment of speaking, the economic situation in the United States appears—on the surface of things—to be highly promising. Even before the outbreak of war abroad, corporate earnings were showing a somewhat unexpected improvement; and now with the added stimulus of war demands the outlook for dividends in the near future appears indeed promising. Production is expanding, employment increasing, purchasing power broadening, and national income rising. The recent increase in food and raw material prices is—in the main—regarded as helpful rather than otherwise, bringing about a better equilibrium between various segments of the economic system. Superficially, at any rate, it would seem that our prayers are at least being answered.

But sober reflection warns of lurking dangers. Are we not stocking up with inventories and expanding production schedules at too rapid a pace? What if the war should end suddenly? Even if it

[1] Presented at General Motors Luncheon, New York City, October 17, 1939.

proves to be of long duration, what will be the ultimate repercussions upon this country? Are we not even now riding the wind and promoting a business boom, with the familiar distortion of prices, wages, and other cost factors? Are we not sure to see sooner or later, and perhaps *sooner* rather than *later,* a new collapse and another protracted period of painful readjustment?

It is no part of my purpose to venture a prediction as to the probable magnitude of the present expansion movement or its possible duration—for I know of no scientific formula whereby one can resolve a compound made up of economic, political, psychological, and military elements, and read the future with unerring eye. My sole object is to discuss what I conceive to be the fundamental economic requirements of the present situation and the industrial policies necessary to achieve the desired ends. I would make it clear at the outset that the analysis is based on the assumption that the United States will not become a participant in the European war.

The National Economic Goal

As a foundation for the consideration of business policies at this time, we should obviously have in mind a clearly defined national economic objective or goal. I would state the desirable objective in the following terms: *The economic goal of the United States at this time should be to make a full utilization of our economic resources in expanding production without permitting a general inflation of prices and a destruction of equilibrium in the economic system.*

Under any circumstances, the maintenance of a well-balanced economy is essential to orderly progress. In view of the present world situation the preservation of financial and ecomonic stability in the United States is a paramount necessity. It is not too much to say that economic developments on the North American continent in the coming months may well prove of decisive importance to the whole future of industrial civilization.

Fundamental Factors in the Economic Situation

If we are to view the national economic problem in fundamental terms, we must look beyond—and for the moment forget—cost accounting and financial issues as they affect particular industries or companies. In other words, we must begin with an engineering approach and survey the national situation in terms of the supplies of primary materials and the capacity of our existing productive plant and equipment to expand output.

The first fact to be noted is that we have exceptionally large accumulated stocks of most primary agricultural and industrial raw materials. Food supplies also have been so large relatively to demand that the trend of prices has been persistently downward. It is unnecessary to present detailed statistical information in respect to food supplies and raw materials, for as everyone knows government agencies, as well as producing groups, have been preoccupied, not with shortages, but with the problem of how to get rid of surpluses "overhanging the markets."

We also had, and now have, the capacity to produce still greater supplies of basic raw materials. In order to keep surpluses down, the government has been restricting agricultural production, while mineral output has been held in check by inadequate demand. In both fields the volume of production could readily be greatly increased. So far as domestic production is concerned, there is thus, in general, no present or prospective shortage of raw materials. (Scrap iron is an important exception.) The situation is, of course, different with respect to materials which have to be imported. It is possible that in some cases serious shortages might develop.

In the fields of manufacture and distribution the situation with respect to productive capacity is similar. Except in a few lines the scale of operation has been far below capacity. Moreover, existing capacity could, if necessary, be expanded without great delay. Railroad facilities might show some temporary shortcomings, but our transportation system as a whole has ample actual or potential capacity to care for probable national requirements.

The situation with respect to labor cannot be stated in such unqualified terms. In the aggregate, unemployment runs into many millions; but a program of business expansion under the stimulus of European war demands would doubtless result in serious shortages of certain types of skilled labor, requiring extensive apprentice training programs. With this reservation, the labor supply must also be regarded as imposing no restriction upon a very large expansion of production.

It is hardly necessary to point out that there is no shortage of what used to be called "the life blood of business," namely money and credit. The supply is superabundant and interest rates the lowest ever known.

There is thus no *scarcity basis* for a great advance

in the general level of commodity prices. Indeed, when one looks at the situation in terms of the effective utilization of productive energy, it would seem clear that as output expands, unit costs of production should, for a time, fall. This is for the simple reason that we would be making use of otherwise idle plant and equipment. When productive resources are not fully employed there is obvious waste; and the elimination of idle resources means —in terms of human energy—a reduction of costs.

But is not the approach that we have been making unreal and impractical in that it ignores the money cost, price, and profit problems which confront individual business enterprises? Obviously, the analysis would be incomplete if it did not give careful consideration to the practical problems which must be faced and solved by business executives who are responsible for meeting payrolls and fixed charges and earning dividends for impatient stockholders. They are not in a position to control the economic system as a whole. They must take cost factors as they find them and make the best profit showing they can, under constantly varying conditions.

Manufacturing industry is, at the moment, confronted with the fact that raw material prices in general are now some 10 per cent higher than in August, and that in many cases the advance has been as much as 25 per cent. Regardless of the situation with respect to aggregate national productive capacity, higher material prices mean for manufacturing enterprises higher money outlays, which cannot be ignored in a profit-making economic system. Before attempting to indicate the bearing of such increased costs on profits, a brief analysis should be made of the factors involved in the advance in raw material prices.

The sharp increase which has occurred in the prices of raw materials is the result of demand from two sources: (1) from speculators seeking to make profits by anticipating price advances based on expectations of war-time inflation; and (2) from industries desiring to expand inventories to take care of immediate and prospective requirements. The speculative element enters here also, since an expected price advance prompts heavy advance buying.

While available data are far from adequate, there is much reason for believing that the great upsurge in raw material buying which has occurred since August has resulted in a greater price advance in many raw materials than is warranted by the fundamental supply and demand factors in the situation. Much of the speculative buying has been based upon exaggerated notions about world wide inflation. Inventory purchases have also been on a plane which may well be above that warranted by the demand from ultimate consumers. There is clear evidence that the current level of *production* is substantially above the current level of *consumption*. While consumptive demand may be expected to increase as employment expands, the question remains. Has not inventory accumulation once again been excessive? The answer will depend in no small degree on the probable magnitude of European war demands.

Factors Affecting European Demands

European purchases may well be of a much more restricted character than has been generally assumed. The present situation differs from that of the World War period in several significant respects. First, the capacity of the principal European nations to buy goods in our markets is very much less. In 1914 their ability to borrow appeared almost limitless, whereas today it is gravely impaired. It is possible to compute for England and France many billions of foreign purchasing power by counting all of the gold resources of these countries held at home and in the United States, and by including investments, bank deposits, and speculative holdings of British and French citizens abroad. However, to mobilize these individual holdings, it is necessary for the governments concerned to obtain possession of them through requiring their exchange for government bonds. In view of the credit strain with which these countries are confronted, the mobilization of these holdings is not a simple matter. Moreover, it is in any case of the utmost importance for these countries to preserve, just as far as possible, their liquid financial resources. Accordingly they may be expected to use such resources just as sparingly as possible.

The advance in prices in 1915 was greatly enhanced by frantic competition among European buyers, participated in both by individual purchasers and by governments. This time the purchase of American supplies will come from fewer countries and they will be pooled in the interest of interallied economy. At the same time rigorous measures for controlling prices are being instituted at the very beginning of the conflict. In this war the European belligerents are harboring no illusions that normal business can go forward as usual, or that the standards of living of the masses can be

raised or even maintained. British mobilization plans call for a restriction of consumption in the interests of procuring maximum war production and maintaining financial equilibrium.

Finally, the need for *American* materials and supplies may well be much smaller than was the case in the World War. To be sure, there will be intense demands in special lines, notably airplanes and machine tools, causing distortion in our industrial structure. But by and large the demands are likely to be restricted. Both France and England have much larger accumulated supplies of munitions than in 1914, and both countries have greatly expanded their capacity to produce munitions. Belgium and other neutral countries may well be important sources of supply. The Dominions also have increased capacity and will be given preference.

Moreover, there is much reason for believing that the present conflict may not involve infantry and artillery operations of a magnitude comparable to that of the last war when the western front was not protected on both sides by almost impregnable fortifications. If this war is fought by England and France chiefly by means of an economic blockade as both military and economic considerations seem to dictate, French and English purchases in the United States would be of comparatively modest proportions.

Speaking generally, I think it may be safely stated that further advances in raw material prices would not be advantageous to raw material producers. This is because they serve to restrict foreign purchases. The sharp rise which has already occurred both in the prices of raw materials and foodstuffs, intensified for foreign purchasers by the relative rise of the dollar, has played directly into the hands of competing areas. Other sources of supply are naturally being given priority.

The implication of this analysis obviously is that the magnitude of European war demands may well have been misgauged. If so, the increases in production schedules and in raw material prices have overshot the mark. The point I am chiefly interested in is that industrial plans for the near future need not necessarily be based on the assumption that raw material prices are certain to go higher; there is quite as much reason for believing that they may go lower.

Industrial Prices

We now proceed directly to the question of industrial price policy in the present situation. Thus far the prices of manufactured goods have not advanced materially. As a matter of sound policy—in the interest of stability—the managements of leading industries have refrained from marking up prices. However, the sharp advance in the price of numerous classes of raw materials, coupled with more moderate increases in some other cost elements, has been leading many to the conclusion that industrial prices must inevitably be advanced in the not distant future.

There can, of course, be no doubt that if operating costs in manufacturing industry should continue to increase it would eventually be necessary to advance prices in order to prevent the elimination of profit margins. The only question at issue is whether an increase in prices is necessary at this time. It is obvious that no answer can be given to this question that is equally applicable to all lines of business. One can only speak in general terms.

At this place the analysis ties back with our earlier discussion of unutilized productive capacity. Not only do costs, in terms of human energy, fall as unused plant and equipment is put to work but financial costs also decline.

As a result of habitual modes of thinking, there has been a tendency for all of us to overlook the bearing of the volume of output on unit costs and profits. So long as an industry is operating well below capacity, an increase in volume, which distributes the burden of overhead over a larger number of units, will offset large increases in direct operating expenses.

The tremendous importance of volume to nearly any corporation one might care to name is strikingly revealed in the financial data for the expansion period of 1936. In a certain group of companies, for example, an increase in the scale of operations from 53 per cent in the first quarter of 1936 to 69 per cent in the second quarter meant more than a three-fold increase in net earnings. In the interval there was a slight decline in prices. Ten companies in one industry, which operated for the year 1935 as a whole on a 47.9 per cent basis, earned 41 million dollars. In 1936, operating at 67 per cent capacity, they earned 128 millions. Meanwhile, average prices had risen less than 1 per cent. Moreover, during this period, both raw material prices and wages were rising. To carry the story into the first half of 1937, a still increasing scale of operations raised profits still higher, notwithstanding the fact that wages and raw material costs advanced very much more than the prices of finished manufactured product.

The significance of increased volume has long been recognized in connection with such industries as transportation and public utilities. It is regarded as a self-evident proposition that the current expansion in railway traffic will materially improve net earnings, bringing the roads as a whole from the red well into the black. It is not assumed that increases in the cost of fuel, labor, and equipment will promptly necessitate an advance in rates either in the railway or public utility fields. But curiously enough in the case of manufacturing we tend to assume that increases in operating costs must be promptly followed by some, if not proportional, advances in prices. The difference between manufacturing industry and railroads and public utilities is only a difference in degree.

In order not to make too sweeping a generalization, I now emphasize that the importance of the principle under discussion varies widely in different divisions of manufacturing industry. An increase in direct expenses is obviously more important in lines where the cost of labor and materials bulks large in relation to overhead expenses than where the reverse is true. Moreover, the gains resulting from an expansion of output in any industry obviously tend to diminish as maximum capacity is approached.

The argument is often heard both in business and academic circles that the moment costs begin to rise in consequence of the utilization of less efficient plant and equipment a price advance is called for. If such a price increase could be applied only to these last units of supply, something might be said for it. But to hold that the level of costs in the obsolescent portion of an industry's plant and equipment should govern the price of the entire product, seems to me clearly untenable.

When the demand is temporarily so intense as to call for a volume of output in excess of the capacity of the more efficient plant and equipment, one alternative is to hold the selling price where it is in the knowledge that such price will more than cover direct operating expenses in the obsolescent plant, thus contributing something to general overhead. If, however, the obsolescent plant is *so inefficient* as to make it impossible to cover direct out-of-pocket expenses at a level of prices in line with the general state of technological advancement in the industry, this would be *prima facie* evidence that it would be sound policy to refuse further business instead of allowing the whole price structure to be distorted. The result would merely be to postpone a portion of the orders, thereby spreading production more evenly. If there is reason for believing that the high level of demand will prove to be of a sustained character, the need then is for the prompt installation of new low-cost capacity. In any case, genuine industrial progress over the years can be achieved only by constantly applying the results of new scientific and engineering developments to the processes of production. The road to progress is well exemplified in the achievements of one industry during the course of the past fifteen years, in which expanding capital investment and increasing efficiency made simultaneously possible (1) a gradual reduction of prices, (2) an increase of wages, both hourly and aggregate, (3) an increase in employment, and (4) a high level of profits. At the same time, there was continuous improvement in the quality and variety of commodities produced, some of which ministered directly to the satisfaction of human wants and others to increasing productive efficiency in a wide range of other industries. I hasten to add that I am not referring to the automobile industry.

Returning to the present situation, the analysis which we have been making clearly leads to the conclusion that there are no compelling economic reasons why there should be any general advances in prices at this time. It would be presumptuous of any individual, without detailed knowledge of the situation which confronts particular companies, to say that *no* price advances are warranted. But *in general* the increases in raw material prices have not been sufficiently great as to offset the gains resulting from increased volume of output. The price index for raw materials as a whole is even now well below the level of 1935 and 1936, and very much below the level of 1937. Even when account is taken of the high level of wage costs, it does not appear that profit margins are in immediate danger of being snuffed out by high operating costs.

The great need in a period of business buoyancy is to keep the industrial eye fixed upon the second, third, and fourth steps ahead. It should always be borne in mind that an increase in the prices of all those forms of manufactured products which enter into succeeding stages of production appear as costs in each succeeding stage, just as the prices of raw materials appear as costs in the first stage of manufacturing. The process of price advance is cumulative and tends to gain in rapidity as it spreads throughout the entire economic system, and involves

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First Aid for Quarry Workers[1]

By L. M. THOMPSON, M.D.

Assistant National Director—First Aid, Life Saving and Accident Prevention Service—American Red Cross.

• **Though substantial progress has been made in the crushed stone industry during recent years in the field of accident prevention, much can still be done to further reduce human suffering and economic losses resulting from avoidable accidents in quarry operations. In the following article Dr. Thompson lays particular emphasis upon the value of first aid training in the prevention of accidents. His comments should be of decided interest.**

A STUDY of the cement industry's accident record for the year 1938 reveals some very interesting facts. In view of the topic assigned to me, a few of these facts may be briefly reviewed:

1. Twenty per cent of the total injuries occurred in your quarries and mines.
2. Seven of the eleven fatalities were in quarries,—more than all the other departments put together.
3. Twenty-eight per cent of the total injuries were fractures, and more fractures occurred in quarries than in any other department.
4. The severity rate of 8.98 was a sharp increase over the previous year, and almost half of the time charges on which the severity rate is based occurred in the quarries.
5. Severe cuts, burns, and bruises were greater in quarry than any other department, though one suspects that actual burns did not occur there, but were grouped under this heading.
6. Infections in quarry accidents were more than double those in any other department.

That is sufficient to show that the quarry is your bad spot for accidents, as you have doubtless recognized. It is very apparent to an outsider that, from your own figures, First Aid is needed in your quarries.

We define First Aid as the immediate and temporary care given in case of an accident or sudden illness before the arrival of the physician. We assume that a physician will arrive, and that the temporary First Aid rendered will in no way take the place of medical attention. The objects in teaching First Aid are:

1. The prevention of accidents.

2. To train people to recognize the nature and extent of an injury, and to know what to do for that injury.

3. To train people to do the right thing at the right time, and to prevent the injury from being made more serious by improper handling.

Before enlarging on any of these three reasons, I want to know more about the companies here represented. I do not want to take your time by telling you a lot of things you already know, or asking you to do something you are already doing. I know the outstanding place in safety which the cement industry has taken, and I know that some of you know as much about the need of First Aid training as I do. Let me get the picture of this crowd:

1. How many of you have an active program of First Aid training in your plant at the present time?

2. How many of the plants here represented have trained all of their men in First Aid?

3. How many have not had any First Aid training in the past year?

4. How many of you men here hold a First Aid certificate?

With that cleared up, let's get back to the first reason for teaching First Aid,—the prevention of accidents. You may not believe that. You may think of First Aid as something of value only after the accident happens. But we know from many experiences that men who have studied First Aid do not have as many accidents as those who have not. Let us take a recent example.

[1] Presented at the meeting of the Cement and Quarry Section, National Safety Congress, Atlantic City, N. J., October 18, 1939.

The United States Engineers, dredging and repairing the levees on the Mississippi, have kept careful records. For the six months ending March 31st of this year, the Rock Island Division showed over 900,000 man-hours for men who had First Aid training, and nearly 600,000 man-hours for those untrained. The untrained men had twice as many lost days from accidents, twice as high a frequency rate, and four times as high for severity rate. Injuries per 100,000 man-hours were: Trained men, 4. Untrained, 6.7.

Why is this? We do not know the whole answer. We probably must admit that the men who study First Aid are a somewhat better quality of men, but that does not necessarily hold, for frequently the failure to know First Aid was simply due to lack of opportunity. We do know that men trained in First Aid become safety minded. You can put all the safety guards and gadgets on the machines you want to, but until you put them on the man who operates that machine he will find some way to get inside that guard. You can put up all the posters, give all the safety lectures, you can study your plant hazards and improve your housekeeping till the cows come home, and if the men are not safety minded they will still have accidents. First Aid is not the only way to make them safety minded but it helps.

Now let's look at the men. We can't go out and pick up a safety minded gang any time we need one. We have to use what we've got. Studies have shown that of all industrial accidents, only about fifteen per cent involve the machine, and eighty-five per cent are due to a human factor. And of those 15 per cent involving the machine, 75 per cent were caused by the human element and not by a fault in the machine. So the human element is the thing we must worry about if we want to prevent accidents. We know there are accident-prone individuals, we record accident-prone periods of the year in some industries, and some of us even suspect that there are accident-prone days when some local condition makes men careless or inattentive.

Look at it another way. For every fatal accident there are 30 lost time accidents and 300 personal injury accidents. And for each of these 330 actual accidents it is estimated there are 50 near accidents. What was it that made the difference between a near accident and a real accident? Once again the human element. And these near accidents can teach us a lot. Men will talk about their near accidents, but they will not talk when someone is dead or hurt. They hesitate to put the finger on a real injury, but they will tell you who was to blame for a near accident.

People have accidents from lack of knowledge and from lack of experience. I did my hospital service up in the anthracite field of Pennsylvania, and they used to say in the mine that it is the new man who gets hurt. They said 48 per cent of the accidents come in a man's first two months, or that a man has as much chance of getting hurt in the first 2 months as in the next 20 years. Another old mine foreman put it: "One quarter in the first week, three quarters in the next 20 years."

What has all this to do with First Aid? Well, it means that you must start your new men with training in their jobs, and that training must include First Aid at the outset if you want to reduce accidents most effectively. There is a powerful lot of argument in the sight of a good bloody accident. If by First Aid training you can put that picture in a man's mind, without having to pay the compensation that goes with a real accident, you are that much ahead.

You can't do much to change the habits of the old timer. He will probably laugh at some of your safety measures. He has learned by hard knocks, and he doesn't want some young college guy telling him how to handle hard rock. But the very fact that he is an old timer in a hazardous industry means that he has somehow developed a philosophy of safety and has learned caution, and timing as well as the skill of his trade, and has become safety minded,—in his own way, perhaps—but still pretty safe. Let us see to it that the old boy graduates into less hazardous jobs before his failing faculties make him dangerous.

But let's get back to our accidents. The second reason for learning First Aid is to train men to recognize the type of injury and to know the appropriate care that is necessary. Fractures come first in your quarry accidents,—more than a quarter of all your accidents. That is a very unsually high percentage, and is the strongest argument I know for First Aid in quarries. Now fractures are not usually fatal, and there is not the need for such immediate care as there is in the case of hemorrhage or stopped breathing. If a fracture victim can be left where he fell until a doctor gets there, and the wait is not too long or too cold, wait for the doctor. But in industry or in traffic we usually cannot do that. An injured man slows up the job, and is bad for morale, and must be gotten out of the way. And if a fracture case must be moved, even for a very short distance, SPLINTS MUST BE APPLIED FIRST. That means First Aid training is

necessary. If the men have not all had this training they will probably pick him up without splints and then the damage may be very greatly increased, and up go your costs.

The Committee on Fractures of the American College of Surgeons has for years been teaching: "Splint them where they lie," and they advocate for fractures of the long bones the use of fixed traction splints. We have not the time to go into the matter of how to apply splints or to argue about the type of splints, but let me urge you to find out about traction splints. The fundamental mechanics of traction ought to appeal to you engineers. From a surgical viewpoint I can assure you that traction splints will reduce pain and shock and shorten recovery time, and can be applied by the trained First Aid man better than any other type of splint for the long bones. In one series of fifty fractures of the thigh in which traction splints were applied by laymen as First Aid, it is reported that these men left the hospital on an average of three weeks earlier than similar fractures splinted with the old type of padded boards. Improvised materials available around any plant may be used for traction splints almost as effectively as the manufactured metal splints, and at practically no cost.

But the main point is this: Somebody must know how to put on splints properly before that man is moved, or it will cost the man agony and lost time, and it will cost the company money. A simple fracture badly handled may become a compound fracture, followed by infection. Or the poor handling without splints may cause a nerve to be cut, and paralysis will follow, with permanent total disability. First Aid training will often prevent this by careful and correct handling, adequate splinting, and proper transportation.

Fractures of the spine are frequently overlooked. They are usually picked up by untrained persons, who mean well and are trying to help. But they do not recognize the symptoms, permit the back to bend and buckle, and permanent paralysis, either partial or complete, may be expected. Dislocations may be worse than fractures in the lost time resulting, and untrained attempts at "fixing" a dislocation may give permanent disability.

Severe bleeding may be fatal in a very short time if nobody is present who knows what to do. A trained First Aid man should be able to control hemorrhage immediately by pressure at the recognized pressure point, or by the application of a pressure dressing on the wound, or, in extreme cases, by a tourniquet. But tourniquets in the hands of untrained men may result in gangrene, amputation, and permanent disability. So First Aid is certainly needed at once in all cases with severe bleeding.

Infections rate unusually high in your quarry accident statistics. It is usually the little injuries that make the big infections. In case of a big injury the victim always sees the doctor. It is the little cuts and scratches, the little blisters and splinters, the minor and neglected injuries that later develop into the severe infections. Prompt application of a suitable antiseptic and dressing by trained First Aid men should greatly reduce the number and severity of these infections.

Your industry had four deaths from electrocution last year, and three of these were in the quarries. Probably the sand and gravel companies had some suffocations due to under-cutting and slides, of which I have no record. Certainly there is need for training in artificial respiration so that these cases may be made to breathe and so be kept alive until the paralysis of the breathing center wears off. These men may be kept alive by artificial respiration, sometimes for many hours, until they are able to breathe for themselves. Without First Aid training and prompt action by others, these men may be dead by the time the doctor arrives. Somebody on the spot must be ready to jump in at once and start working, and that means that all your men need to know how to give artificial respiration.

May I suggest as a side factor, that since many of your high accident months have come in the summer, that you make a study of the possibility of salt deficiency as a cause of accidents? Not only will the use of salt prevent heat prostration and heat cramps, but by the prevention of muscle cramps and general fatigue it may be a factor in reducing accidents in your quarries in hot weather, or in fact any time when men perspire freely.

You know the four danger spots which gave you 90 per cent of your severe accidents last year,—moving machinery, high places, electricity, and railroads. All these occur in your quarries. First Aid is necessary in all the accidents associated with these four great factors for evil.

More important than that, however, is the fact that the training of your men in First Aid should result in a marked reduction of accidents by their actual prevention in these particular four hot spots. There seems to have been some tendency to let up on First Aid training during the hard times of the past few years. Some plants have felt that they could not

afford to teach First Aid. First Aid contests have been given up, and I fear some plants only taught First Aid with the hope of winning a contest! But if you will study the results in those plants where First Aid training has been continued and is compulsory, you will see that you cannot afford not to teach First Aid.

Regardless of how complete your safety organization may be, how perfect your medical department and its equipment,—it is the safety gadget you have put in the minds of your men that counts. Your program cannot give you the best results until you have in some way made your men safety minded. First Aid training will do just that. It is not the only way, perhaps, but it is a way. Try it.

Industrial Price Policies in This Emergency

(*Continued from page 18*)

wage as well as price advances. Accordingly, if the well-known vicious spiral is to be checked, it must be checked in its early stages.

At the beginning of this address it was stated that the economic goal of the United States at this difficult and uncertain period should be to make a full utilization of our economic resources in expanding production without permitting a general inflation of prices and a destruction of equilibrium. If this national objective be accepted, it follows that advances in industrial prices at this time should be resisted to the utmost. We should be content to make increased profits by a fuller and a steadier utilization of capacity, and by ever-increasing efficiency in production.

Similarly, labor policy in this emergency should be focused upon the realization of gains through more and steadier employment instead of upon hourly wage increases. The advances in hourly wages during recent years have not been accompanied by corresponding increases in weekly wages.

On the contrary, weekly and annual wages have on the whole declined. A far-sighted labor policy can also contribute much to the maintenance of financial stability.

The only *real* profits, like the only *real* wages, are those which arise from increased production. Speculative profits resulting merely from purchasing goods at one price and selling them at an advance are not of a constructive character; that is, they are not backed by tangible goods and services and thus add nothing in primary terms to the wealth of society. Moreover, such profits are in the main illusory—for when utilized in the replenishment of inventories or the construction of new plant and equipment which have also risen in price, a dollar of profits will not go as far as before. Thus the apparent gains are nullified. Meanwhile, thanks to our system of accounting, a substantial portion of these paper profits may be gathered by the tax-collector. In any case, such price advances, as our industrial history proves, lead to collapse and depression, the losses of which more than offset any temporary gains that may have been realized.

If all groups in the body politic will work together at this juncture in clear realization of the fundamental requirements of the situation, it will be possible not only for all classes of the American people to receive higher levels of real income, but also for this nation to maintain financial and economic stability, and thereby make its most effective contribution to the eventual restoration of economic stability and progress in the world as a whole.

Research Needed on Accelerated Weathering Tests

(*Continued from page 13*)

may proceed through the concrete by capillary action and, as previously discussed, this may have an important effect on the kind of freezing action which takes place in the concrete. Freezing tests under conditions of this kind should be conducted to determine how important they may be.

A complete discussion of the subject of concrete durability was not intended in the present article, but rather was it hoped that through a few random thoughts, the desirability of a thorough study of accelerated soundness tests might be shown. Our present accelerated soundness tests of aggregates or of concrete are neither adequate nor complete. They neglect a number of the influences above discussed. A systematic attempt should be made to outline and carry out a complete investigation involving the influences which are important in connection with the durability of concrete so that finally we might evolve satisfactory laboratory tests which will enable us to predict whether the constituent materials of concrete or whether the concrete itself will be suitable for the particular exposure conditions to which it will be subjected.

Interest of the War Department in Highway Construction and Development[1]

• With the United States Government now engaged in a preparedness program of major proportions the following authoritative discussion concerning the interest of the War Department in highway construction should prove of unusual interest.

GENERAL STRONG, Assistant Chief of Staff, War Plans Division, originally scheduled to give this talk, sends you his greetings and wishes me to express to you his sincere regret that he is unable to be present today. He is detained in Washington on emergency business arising from the present international situation. Since he was unable to come, I have been delegated to act for him.

Roads have always exerted an important influence in military campaigns. Frequently the road net has been the controlling factor in tactical movements on the field of battle. Both strategical and tactical plans are limited by roads, since freedom of maneuver depends upon their number, quality, location and direction. In battle, two parallel streams of traffic flow to and from the front; one of men, munitions and supplies moving forward; the other of empty vehicles and the wreckage of war moving toward the rear. These two streams of axial traffic are crossed by other traffic, roughly parallel to the front, caused by the movement of reliefs, reserves and the distribution of supplies. If either the axial traffic or the movement of men and supplies along the front is seriously obstructed, confusion and impairment of battle efficiency is the inevitable result.

Influence of Roads on Military Campaigns

The history of warfare affords numerous examples of the influence that roads exert on campaigns. In the Gallic Wars, Caesar found it necessary to build roads so stable that they have carried all sorts of vehicles for a period of 2000 years. The success of his legions can be attributed, in great part, to the freedom of maneuver and the supply system made possible by the Roman roads. In the Wilderness Campaign of the War Between the States, Grant's supply system all but collapsed on account of the poor roads in that area. The great "Valley Pike" of Virginia is inseparably linked with the fame of Stonewall Jackson. Probably the most outstanding example and one with which many of you are familiar occurred during the World War. The motor truck line which supplied Verdun was a creation born of necessity and not contemplated by the German General Staff. The German plans inferred that the Verdun garrison could be isolated and defeated. The railroad line from the west was already under the fire of their guns and the important line from the south had been put out of commission by the St. Mihiel salient. Only one narrow gauge railway and one road remained open. Quick to grasp the situation, the French collected the motor transportation of the Second and Third Armies and pressed it into service on the road from Bar-le-duc to Verdun. In a short time, trucks were hauling 12,000 troops and 2,000 tons of munitions daily along this route. 6,000 trucks passed a given point in 24 hours. One in every 14 seconds, rising at times to one every five seconds. To Frenchmen this road is now known as the "Sacred Way."

The history of the American Army is closely associated with the road system of the United States. In 1754, Colonel Washington and his little party of Virginians followed an Indian path across the Allegheny Mountains to the defense of Ft. Duquesne. Later, General Braddock marched his ill-fated British troops over a part of this route. Years later the Cumberland Road or National Pike was built by the War Department over this same military road for a considerable distance. This national highway soon became one of the great commercial roads of the nation. The lack of adequate highway facilities was a constant problem in the defense of the western frontiers. As early as 1819, resolutions were passed by Congress calling upon the Secretary of War, Mr. Calhoun, to report on the roads necessary for national defense. Parenthetically, it may be said that his report was not favorably considered. Many of the early roads which were constructed by the Army during the frontier days for defense purposes later

[1] Presented by Lt. Col. Paul E. Tombaugh, Acting for Gen. Geo. V. Strong, before the American Association of State Highway Officials at Richmond, Virginia, October 11, 1939.

became important trade routes for the territory. With the increase in settlers and the development of the country, civil rather than military needs became of primary importance.

However, the needs of national defense have not been disregarded in the development of our highway system. It is gratifying for me to express publicly, at this time, the appreciation of the War Department for the sympathetic interest shown by the Public Roads Administration and the State Highway Departments in national defense needs. The most cordial relations have existed for many years between the War Department and the Public Roads Administration. The close collaboration between the two agencies, and the wholehearted cooperation shown by Mr. MacDonald and his staff, have made the solution of national defense highway problems much easier than would be possible under other conditions.

War Department Makes Study of Highways for National Defense

In order to advise the State and Federal agencies relative to highways of value to national defense, a study was completed by the War Department in collaboration with the Public Roads Administration in 1922. This study was based upon certain general principles mutually agreed upon by the War Department and the Public Roads Administration. The most important of these were—

First, that the highways which must be constructed for commerce and national development will, in general, be identical with those required for military purposes;

Second, that the location of highways and the priorities of construction is a matter for determination by the Public Roads Administration and the State Highway Authorities concerned. This being the case, the War Department ordinarily refrains from recommending specific highway routes except in the most critical strategic areas;

Third, that a general net-work of good roads connecting important depots, mobilization and industrial centers, has more strategic value than trans-continental roads which merely cross the country from coast to coast or from north to south. In this connection, a system of high-standard roads connecting our principal centers of production with vital strategic areas has considerable commercial, as well as military, value;

Fourth, that the War Department's primary interest is in insuring adequate highway facilities between important strategic points and vital areas.

As a result of that study the so-called "Pershing Map" showing highways of strategic importance was printed in 1922. The map was revised in 1935 and the latest revision, now called the War Department Special Highway Map, was approved by the Chief of Staff last month. This map was prepared in close collaboration with the Public Roads Administration and the roads indicated thereon coincide in so far as practicable with existing highways. It should be noted here that the general routes shown are not, as so frequently stated, military roads. There are no military roads, as such, in the Continental United States. Instead, the primary purpose of the Special Highway Map is to provide your State Highway Departments and the Public Roads Administration with information concerning important strategic roads. It is hoped, in the interest of national defense, that the general routes indicated and the standards of construction desired will receive favorable consideration in your highway development program.

Standards of Construction Established

The standards of construction desired are as follows:

Surface—Hard surface, capable of supporting 9,000 pound wheel load on pneumatic tires.

Width—Minimum of 20 feet. Bridges to be four feet in excess of approach roads.

Bridge Load Capacity—Minimum H-15 loading.

Grade—Non-mountainous areas, maximum of 5 per cent in lengths greater than 500 feet; mountainous areas, maximum of 8 per cent in lengths greater than 500 feet.

Curvature—Non-mountainous areas, maximum of 6 degrees; mountainous areas, maximum of 14 degrees.

Vertical clearance—Minimum of 14 feet.

Sight Distance—Non-mountainous areas, minimum of 1,000 feet; mountainous areas, minimum of 650 feet.

War Department agencies responsible for the design of military vehicles will give full consideration to

the limitations on weight, height and wheel load imposed by the foregoing standards.

The cooperation of the local communities, states, and Public Roads Administration has already provided many essential high-standard strategic roads in most sections of the United States. These highways would be of inestimable value in the event of a national emergency. However, some sections of this strategic system still need improvement. It is understood that the Public Roads Administration is now conducting a survey to obtain information regarding the existing deficiencies of these important roads.

In addition to the strategic highway project, the War Department Committee, which was recently appointed by the Chief of Staff to collaborate with the Public Roads Administration and your Highway Transport Committee, has under consideration—

a. Highway requirements in the neighborhood of military posts and garrisons, especially in the vicinity of proposed mobilization centers, and

b. The highways necessary to serve traffic requirements in important war-time industrial areas.

For convenience, roads which are needed in the vicinity of military posts and proposed concentration centers are called access roads. In many instances these are inadequate in number and far below the standards that would be needed in the event of an emergency. As a rule they are comparatively short in length and inexpensive to construct. Considerable information has already been assembled with respect to the access roads required. However, further detailed local studies will be necessary. The information available has already been furnished the Public Roads Administration. Their construction would facilitate troop training and diminish traffic hazards in congested training centers. The War Department recommends that the State Highway Authorities and the Public Roads Administration give consideration at this time to the construction of these essential access roads.

With respect to highway facilities in important industrial areas, the War Department has already furnished the Public Roads Administration information concerning the probable industrial load which would be generated by war-time procurement. When this is translated into the probable increase in highway traffic it should provide you with information for use in connection with future highway development programs in those areas. In some centers, industrial mobilization would probably result in considerable highway traffic congestion.

I have mentioned the importance of roads in the conduct of military operations in the past. Obviously that importance is not diminished by the broad programs for motorization and mechanization now under way. We have progressed from the ox-cart at two miles per hour to the staff car at seventy miles per hour; from a division marching twenty miles per day to a division with more than 1,300 vehicles, capable of marching 320 miles in fourteen hours. Orders have just been issued for the reorganization and "streamlining" of five regular army divisions. Supply trains and cavalry on wheels, move farther and faster. Today mobility, speed, and fire power are of paramount importance. Adequate roads will increase mobility and enable a commander to concentrate his fire power with greater speed. Our Army is small in numbers, almost insignificant, in comparison with the masses of troops assembled by other World Powers. There is all the more reason, therefore, that our highways and other means of transportation should be adequate to permit swift concentration, at maximum strength, at any point that may be threatened.

Summary

To summarize, from the military viewpoint:

First, existing deficiencies in the strategic system should be eliminated.

Second, in so far as practicable and consistent with commercial needs, projects for the construction of essential access roads deserve favorable consideration.

Third, highway facilities in important industrial areas should be adequate to meet the highway traffic requirements of wartime industrial procurement.

In these uncertain days when our national security assumes increasing significance, I am sure that each of you, whether in public or private life, wishes to contribute his full share to our national defense. All of us, whether in the War Department, the Public Roads Administration, the State or County highway departments, or private individuals, are working toward a common end. That end is to insure the security of America against any emergency that may arise. In working toward that common end, each one of us is contributing materially to our national defense.

Some State Highway Trends

WE ARE indebted to "Highway Extension Notes," issued by the Engineering Extension Department, Purdue University, Ben H. Petty, Editor, for the following highly interesting and valuable information covering state highway trends, based on a survey conducted by the *Engineering News-Record* and reported in its Annual Highway Number.

This report, according to Highway Extension News, shows that the 48 states in 1938 invested one-third of their highway money in maintenance and equipment, and two-thirds in new construction. These preliminary estimates of state highway expenditures for 1938 total approximately $735,000,000, of which $493,000,000 was spent for construction and $242,000,000 for maintenance and equipment. On this basis, each American in 1938 spent through his various state highway departments an average of $5.68, of which $4.01 was for new highway improvement and $1.97 was for maintenance and equipment.

During 1938 the 48 states constructed 28,310 miles of highway, of which 12.3% was hard pavement, 52.7% bituminous types, and 35% graded, drained, and other untreated surfacing types.

On the basis of mileage of hard surface pavements constructed in 1938, the first 10 states rank as follows:

1 and 2.	Mississippi and Texas	330 miles each
3.	Iowa	292 "
4.	New York	217 "
5.	Indiana	197 "
6.	Illinois	194 "
7.	Kentucky	167 "
8.	Virginia	154 "
9.	Pennsylvania	143 "
10.	Ohio	129 "

It is interesting to note from these data that each of the following 19 states constructed less than 25 miles of hard surface pavement last year:

Maine	South Dakota*
New Hampshire	Montana
Vermont	Wyoming*
Massachusetts*	Colorado*
Rhode Island	New Mexico*
Connecticut	Idaho
West Virginia	Utah
Alabama	Arizona
North Dakota*	Nevada*
	Washington

*None

The trend toward use of increasing percentages of total highway expenditures for maintenance is quite noticeable. For instance, in 1936, 27% of the combined construction and maintenance funds was assigned to maintenance as compared to 29% in 1937 and 33% in 1938. The New England group of states reported the highest maintenance ratio, 46%, while the Southern group reported the lowest ratio, 25%.

The following table presents interesting information on maintenance and construction percentages in the various state groupings.

State Groupings	Expenditure Ratios Within the Group		Based on Total Expenditure of 48 States	
	Maint. and Equip. %	Const. %	% of Total on Maint. & Equip.	% of Total on Const.
New England	46	54	9	6
Middle Atlantic	41	59	21	15
Southern	25	75	19	27
Middle West	36	64	17	15
West of Mississippi River	30	70	23	26
Far West	31	69	11	11

The construction of highways by types in the various state groupings presents an interesting picture. This is illustrated in the following table.

State Groupings	% Graded and Drained and Other Untreated Surfaces	% Bituminous	% Hard Surface
New England	24	71	5
Middle Atlantic	28	39	33
Southern	30	55	15
Middle West	23	54	23
West of Mississippi River	44	48	8
Far West	31	65	4

The following table shows the miles by types of roads constructed by the various state highway departments in 1938 and the per cent of increase or decrease by types as compared to 1937.

Type	Mileage	Per cent	% Variation from 1937
Hard Surface	3,495	12.3	−3
Bituminous	14,947	52.7	+65
Graded and Drained and Other Untreated Surfaces	9,868	35.0	−41
Total	28,310	100	−4

The following quotation from *Engineering News-Record* is most significant: "Increasing use of bituminous types of surfacing and a larger proportion of highway money assigned to maintenance are the principal trends revealed by the year's state highway mileage and expenditure statistics reported to *Engineering News-Record* by 48 state highway departments."

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Gasoline, Diesel, Electric Steam Locomotive Cranes, Crawler Cranes and Shovels

Pettibone Mulliken Corp.
4710 West Division St., Chicago, Ill.

Pit and Quarry Publications
538 South Clark St., Chicago, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Industries Yearbook

Robins Conveying Belt Co.
15 Park Row, New York City
Belt Conveyors, Bucket Elevators, Gyrex and Vibrex Screens, Feeders, Design and Construction of Complete Plants

Rock Products
205 West Wacker Drive, Chicago, Ill.

Ross Screen and Feeder Co.
19 Rector St., New York City
Ross Patent Chain Feeders for Feed Control of All Sizes Rock, Ores, Gravel, etc.

Screen Equipment Co.
9 Lafayette Ave., Buffalo, N. Y.
SECO Vibrating Screens

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screen, Simplicity D'centegrator, Simplicity D'watering Wheel

Smith Engineering Works
E. Capitol Drive at N. Holton Ave., Milwaukee, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Stephens-Adamson Mfg. Co.
Aurora, Illinois
Complete Stone Preparation Plants, Conveying, Elevating, Screening, Transmission Equipment

Taylor-Wharton Iron & Steel Co.
High Bridge, N. J.
Manganese and other Special Alloy Steel Castings

The Texas Co.
135 E. 42nd St., New York City

The Thew Shovel Co.
Lorain, Ohio
Power Shovels, Cranes, Crawler Cranes, Locomotive Cranes, Draglines. Diesel Electric, Gasoline. 3/8 to 2-1/2 cu. yd. capacities

The Traylor Engineering & Mfg. Co.
Allentown, Pa.
Stone Crushing, Gravel, Lime and Cement Machinery

Troco Lubricating Co., Inc.
2728-34 N. Salmon St., Philadelphia, Pa.
Troco Crusher Grease, Troco Safety Lubricants

Trojan Powder Co.
17 N. 7th St., Allentown, Pa.
Explosives and Blasting Supplies

The W. S. Tyler Co.
3615 Superior Ave., N. E., Cleveland, Ohio
Wire Screens, Screening Machinery, Scrubbers, Testing Sieves and Dryers

Warren Brothers Roads Co.
P. O. Box 1869, Boston, Mass. or
38 Memorial Drive, Cambridge, Mass.
Complete plants and separate plant units for bituminizing all types of stone, sand and gravel aggregate paving mixtures

23rd

ANNUAL CONVENTION and EXPOSITION

NATIONAL CRUSHED STONE ASSOCIATION

Hotel Jefferson . . . . St. Louis, Mo.

JANUARY 22, 23 and 24, 1939

ONCE a year Crushed Stone producers of the United States and Canada are afforded the opportunity of participating in one of the major activities of their trade association—the annual Convention and Exposition.

Papers may be printed, but no substitute can ever take the place of actually hearing a speaker deliver his message, and the speakers who will appear on the program of this 23rd Convention of the National Crushed Stone Association are carefully selected for their outstanding ability and thorough understanding of the subjects which they will present.

The same applies to the Exposition. No photographs, no matter how good they may be, no descriptions, regardless of their excellence, can serve as a substitute for the ability to actually examine the wide range of machinery and equipment that will be brought together in St. Louis for your inspection.

You are cordially invited to attend—whether or not you are a member of the National Crushed Stone Association—mark the dates on your calendar, January 22, 23, 24, 1940, Hotel Jefferson, St. Louis, Mo.

NATIONAL CRUSHED STONE ASSOCIATION

1735 Fourteenth Street, N.W. . . . Washington, D. C.